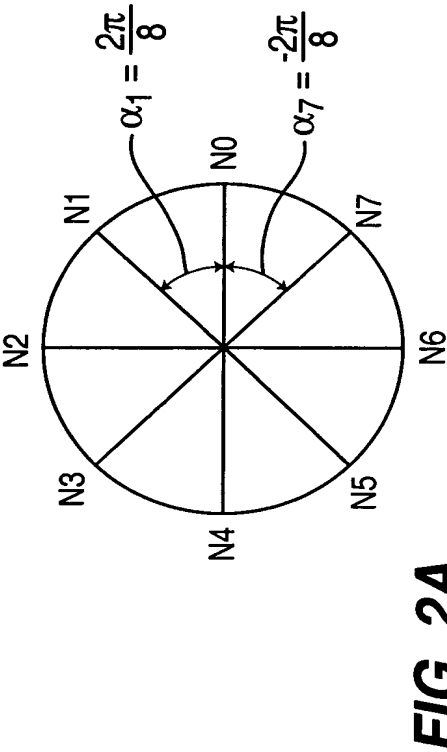


FIG. 1



8 POINT DFT

SET	Real Twiddle Factors								Imaginary Twiddle Factors							
	N0	N1	N2	N3	N4	N5	N6	N7	N0	N1	N2	N3	N4	N5	N6	N7
0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	1	0.707	0.000	-0.707	-1.000	-0.707	0.000	0.707	0.000	0.707	1.000	0.707	0.000	-0.707	-1.000	-0.707
2	1	0.000	-1.000	0.000	1.000	0.000	-1.000	0.000	0.000	1.000	0.000	-1.000	0.000	1.000	0.000	-1.000
3	1	-0.707	0.000	0.707	-1.000	0.707	0.000	-0.707	0.000	0.707	-1.000	0.707	0.000	-0.707	1.000	-0.707
4	1	-1.000	1.000	-1.000	1.000	-1.000	1.000	-1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	1	-0.707	0.000	0.707	-1.000	0.707	0.000	-0.707	0.000	-0.707	1.000	-0.707	0.000	0.707	-1.000	0.707
6	1	0.000	-1.000	0.000	1.000	0.000	-1.000	0.000	0.000	-1.000	0.000	1.000	0.000	-1.000	0.000	1.000
7	1	0.707	0.000	-0.707	-1.000	-0.707	0.000	0.707	0.000	-0.707	-1.000	-0.707	0.000	0.707	1.000	0.707

FIG. 2B



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$$\begin{aligned} \text{REAL} = & X_R(0)\cos(k_0) + \\ & (X_R(1)+X_R(7))\cos(k_1) + (X_I(1)-X_I(7))\sin(k_1) + \\ & (X_R(2)+X_R(6))\cos(k_2) + (X_I(2)-X_I(6))\sin(k_2) + \\ & (X_R(3)+X_R(5))\cos(k_3) + (X_I(3)-X_I(5))\sin(k_3) + \\ & X_R(4) \cos(k_4) \quad + X_I(4) \sin(k_4) \end{aligned}$$

Ⓑ

Ⓒ

Ⓓ

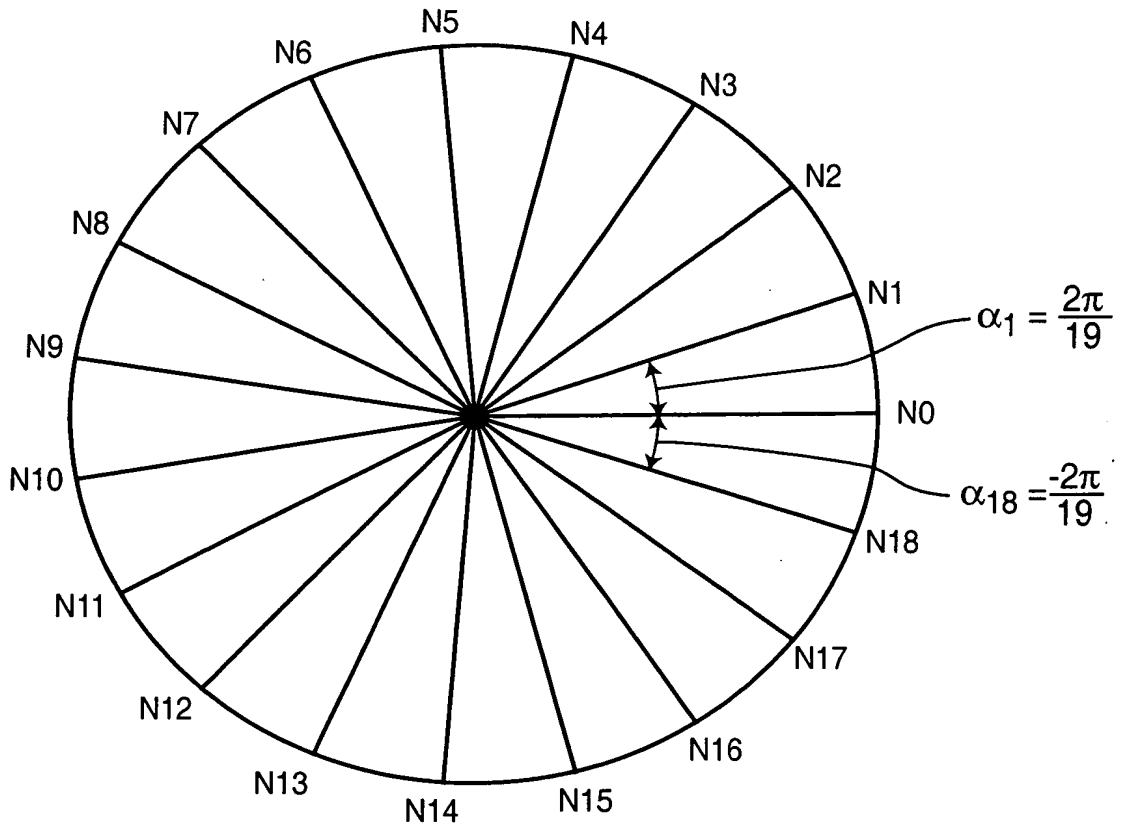
$$\begin{aligned} \text{IMAG} = & X_I(0)\sin(k_0) + \\ & (X_I(1)+X_I(7))\sin(k_1) - (X_R(1)-X_R(7))\cos(k_1) + \\ & (X_I(2)+X_I(6))\sin(k_2) - (X_R(2)-X_R(6))\cos(k_2) + \\ & (X_I(3)+X_I(5))\sin(k_3) - (X_R(3)-X_R(5))\cos(k_3) + \\ & X_I(4) \sin(k_4) \quad - X_R(4) \cos(k_4) \end{aligned}$$

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8 POINT DFT INPUT OPTIMIZATION

FIG. 2C

+

**FIG. 3A**

set	Real Twiddle Factors																		
	N0	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15	N16	N17	N18
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	0.946	0.789	0.547	0.245	-0.083	-0.402	-0.677	-0.879	-0.986	-0.986	-0.879	-0.677	-0.402	-0.083	0.245	0.547	0.789	0.946
2	1	0.789	0.245	-0.402	-0.879	-0.986	-0.677	-0.083	0.547	0.946	0.946	0.547	-0.083	-0.677	-0.986	-0.879	-0.402	0.245	0.789
3	1	0.547	-0.402	-0.986	-0.677	0.245	0.946	0.789	-0.083	-0.879	-0.879	-0.083	0.789	0.946	0.245	-0.677	-0.986	-0.402	0.547
4	1	0.245	-0.879	-0.677	0.547	0.946	-0.083	-0.986	-0.402	0.789	0.789	-0.402	-0.986	-0.083	0.946	0.547	-0.677	-0.879	0.245
5	1	-0.083	-0.986	0.245	0.946	-0.402	-0.879	0.547	0.789	-0.677	-0.677	0.789	0.547	-0.879	-0.402	0.946	0.245	-0.986	-0.083
6	1	-0.402	-0.677	0.946	0.789	-0.083	0.789	0.245	-0.986	0.547	0.547	-0.986	0.245	0.789	-0.879	-0.083	0.946	-0.677	-0.402
7	1	-0.677	-0.083	0.789	-0.986	0.547	0.245	-0.879	0.946	-0.402	-0.402	0.946	-0.879	0.245	0.547	-0.986	0.789	-0.083	-0.677
8	1	-0.879	0.547	-0.083	-0.402	0.789	-0.986	0.946	-0.677	0.245	0.245	-0.677	0.946	-0.986	0.789	-0.402	-0.083	0.547	-0.879
9	1	-0.986	0.946	-0.879	0.789	-0.677	0.547	-0.402	0.245	-0.083	-0.083	0.245	-0.402	0.547	-0.677	0.789	-0.879	0.946	-0.986
10	1	-0.986	0.946	-0.879	0.789	-0.677	0.547	-0.402	0.245	-0.083	-0.083	0.245	-0.402	0.547	-0.677	0.789	-0.879	0.946	-0.986
11	1	-0.879	0.547	-0.083	-0.402	0.789	-0.986	0.946	-0.677	0.245	0.245	-0.677	0.946	-0.986	0.789	-0.402	-0.083	0.547	-0.879
12	1	-0.677	-0.083	0.789	-0.986	0.547	0.245	-0.879	0.946	-0.402	-0.402	0.946	-0.879	0.245	0.547	-0.986	0.789	-0.083	-0.677
13	1	-0.402	-0.677	0.946	-0.083	-0.879	0.789	0.245	-0.986	0.547	0.547	-0.986	0.245	0.789	-0.879	-0.083	0.946	-0.677	-0.402
14	1	-0.083	-0.986	0.245	0.946	-0.402	-0.879	0.547	0.789	-0.677	-0.677	0.789	0.547	-0.879	-0.402	0.946	0.245	-0.986	-0.083
15	1	0.245	-0.879	-0.677	0.547	0.946	-0.083	-0.986	-0.402	0.789	0.789	-0.402	-0.986	-0.083	0.946	0.547	-0.677	-0.879	0.245
16	1	0.547	-0.402	-0.986	-0.677	0.245	0.946	0.789	-0.083	-0.879	-0.879	-0.083	0.789	0.946	0.245	-0.677	-0.986	-0.402	0.547
17	1	0.789	0.245	-0.402	-0.986	-0.677	-0.879	-0.083	0.547	0.946	0.946	0.547	-0.083	-0.677	-0.986	-0.879	-0.402	0.245	0.789
18	1	0.946	0.789	0.547	0.245	-0.083	-0.402	-0.677	-0.879	-0.986	-0.986	-0.879	-0.677	-0.402	-0.083	0.245	0.547	0.789	0.946

19 POINT DFT

FIG. 3B

Imaginary Twiddle Factors																			
set	N0	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15	N16	N17	N18
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0.325	0.614	0.837	0.969	0.997	0.916	0.736	0.476	0.165	-0.165	-0.476	-0.736	-0.916	-0.997	-0.969	-0.837	-0.614	-0.325
2	0	0.614	0.969	0.916	0.476	-0.165	-0.736	-0.997	-0.837	-0.325	0.325	0.837	0.997	0.736	0.165	-0.476	-0.916	-0.969	-0.614
3	0	0.837	0.916	0.165	-0.736	-0.969	-0.325	0.614	0.997	0.476	-0.476	-0.997	-0.614	0.325	0.969	0.736	-0.165	-0.916	-0.837
4	0	0.969	0.476	-0.736	-0.837	0.325	0.997	0.165	-0.916	-0.614	0.614	0.916	-0.165	-0.997	-0.325	0.837	0.736	-0.476	-0.969
5	0	0.997	-0.165	-0.969	0.325	0.916	-0.476	-0.837	0.614	0.736	-0.736	-0.614	0.837	0.476	-0.916	-0.325	0.969	0.165	-0.997
6	0	0.916	-0.736	-0.325	0.997	-0.476	-0.614	0.969	-0.165	-0.837	0.837	0.165	-0.969	0.614	0.476	-0.997	0.325	0.736	-0.916
7	0	0.736	-0.997	0.614	0.165	-0.837	0.969	-0.476	-0.325	0.916	-0.916	0.325	0.476	-0.969	0.837	-0.165	-0.614	0.997	-0.736
8	0	0.476	-0.837	0.997	-0.916	0.614	-0.165	-0.325	0.736	-0.969	0.969	-0.736	0.325	0.165	-0.614	0.916	-0.997	0.837	-0.476
9	0	0.165	-0.325	0.476	-0.614	0.736	-0.837	0.916	-0.969	0.997	-0.997	0.969	-0.916	0.837	-0.736	0.614	-0.476	0.325	-0.165
10	0	-0.165	0.325	-0.476	0.614	-0.736	0.837	-0.916	0.969	-0.997	0.997	-0.969	0.916	-0.837	0.736	-0.614	0.476	-0.325	0.165
11	0	-0.476	0.837	-0.997	0.916	-0.614	0.165	0.325	-0.736	0.969	-0.969	0.736	-0.325	-0.165	0.614	-0.916	0.997	-0.837	0.476
12	0	-0.736	0.997	-0.614	-0.165	0.837	-0.969	0.476	0.325	-0.916	0.916	-0.325	-0.476	0.969	-0.837	0.165	0.614	-0.997	0.736
13	0	-0.916	0.736	0.325	-0.997	0.476	0.614	-0.969	0.165	0.837	-0.837	-0.165	0.969	-0.614	-0.476	0.997	-0.325	-0.736	0.916
14	0	-0.997	0.165	0.969	-0.325	-0.916	0.476	0.837	-0.614	-0.736	0.736	0.614	-0.837	-0.476	0.916	0.325	-0.969	-0.165	0.997
15	0	-0.969	-0.476	0.736	0.837	-0.325	-0.997	-0.165	0.916	0.614	-0.614	-0.916	0.165	0.997	0.325	-0.837	-0.736	0.476	0.969
16	0	-0.837	-0.916	-0.165	0.736	0.969	0.325	-0.614	-0.997	-0.476	0.476	0.997	0.614	-0.325	-0.969	-0.736	0.165	0.916	0.837
17	0	-0.614	-0.969	-0.916	-0.476	0.165	0.736	0.997	0.837	0.325	-0.325	-0.837	-0.997	-0.736	-0.165	0.476	0.916	0.969	0.614
18	0	-0.325	-0.614	-0.837	-0.969	-0.997	-0.916	-0.736	-0.476	-0.165	0.165	0.476	0.736	0.916	0.997	0.969	0.837	0.614	0.325

19 POINT DFT

FIG. 3C

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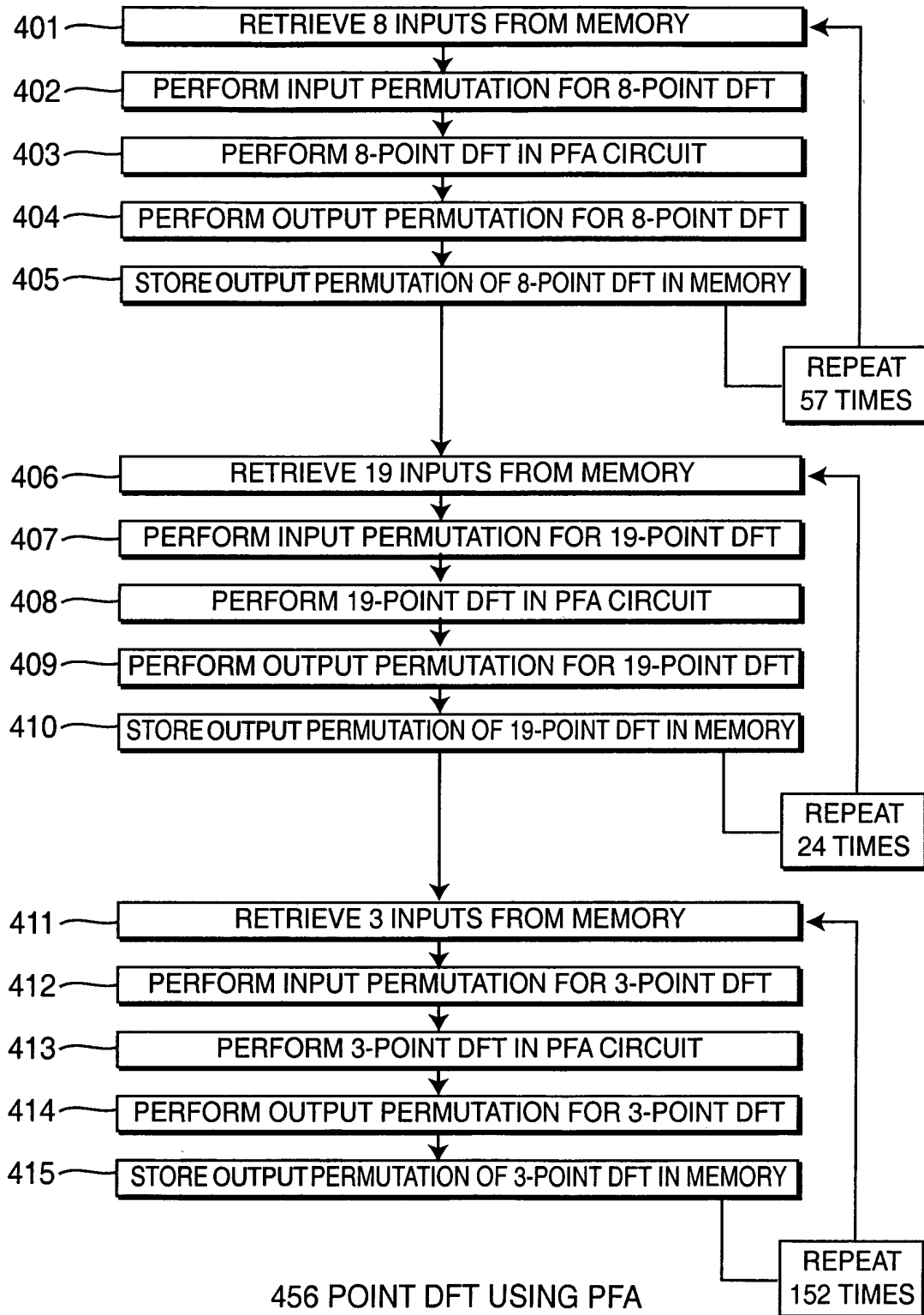
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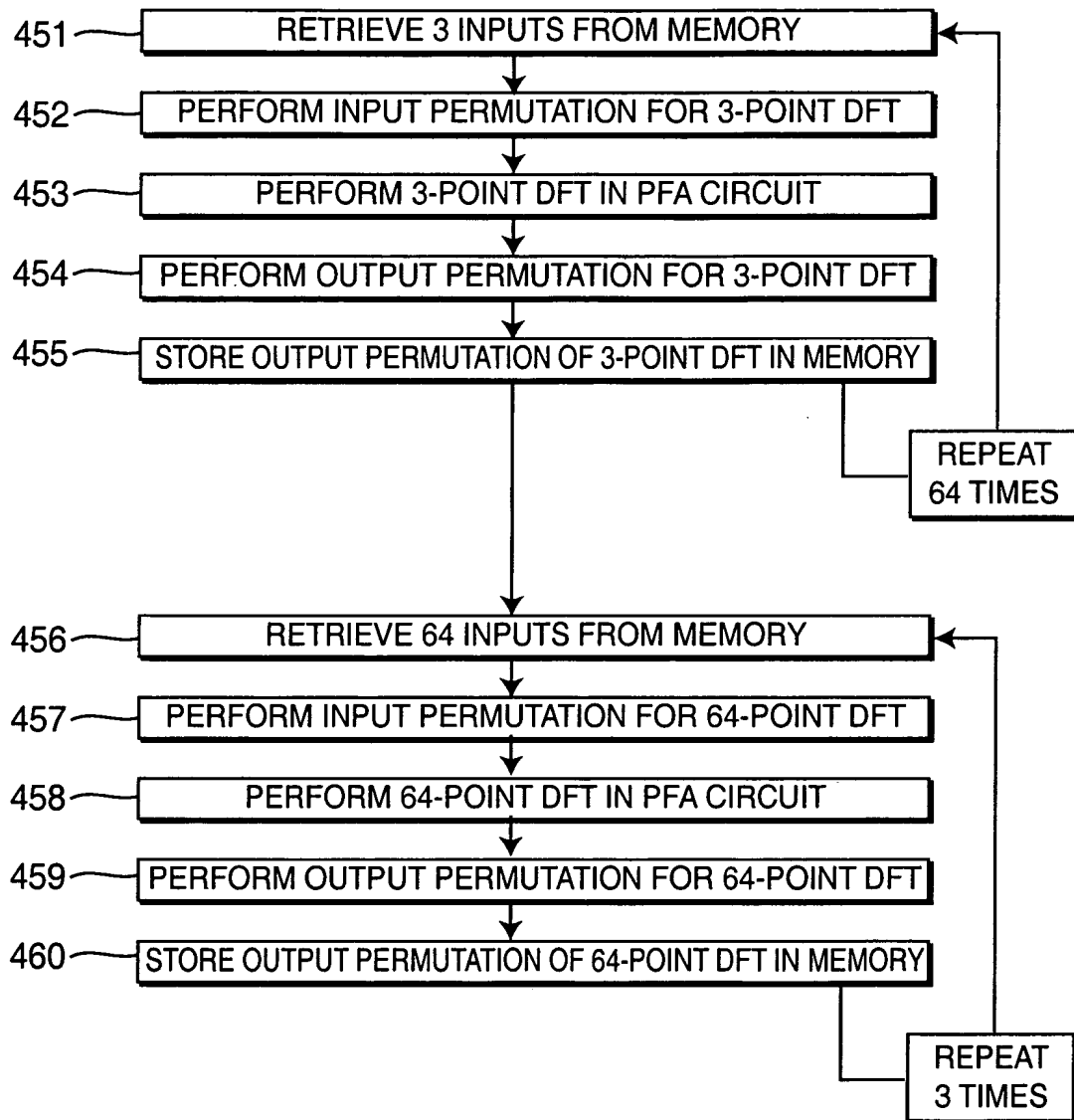
$$\begin{aligned}
 \text{REAL} &= X_R(0)\cos(k_0) + \\
 &(X_R(1)+X_R(18))\cos(k_1) + (X_I(1)-X_I(18))\sin(k_1) + \\
 &(X_R(2)+X_R(17))\cos(k_2) + (X_I(2)-X_I(17))\sin(k_2) + \\
 &(X_R(3)+X_R(16))\cos(k_3) + (X_I(3)-X_I(16))\sin(k_3) + \\
 &(X_R(4)+X_R(15))\cos(k_4) + (X_I(3)-X_I(15))\sin(k_4) + \\
 &(X_R(5)+X_R(14))\cos(k_5) + (X_I(5)-X_I(14))\sin(k_5) + \\
 &(X_R(6)+X_R(13))\cos(k_6) + (X_I(6)-X_I(13))\sin(k_6) + \\
 &(X_R(7)+X_R(12))\cos(k_7) + (X_I(7)-X_I(12))\sin(k_7) + \\
 &(X_R(8)+X_R(11))\cos(k_8) + (X_I(8)-X_I(11))\sin(k_8) + \\
 &(X_R(9)+X_R(10))\cos(k_9) + (X_I(9)-X_I(10))\sin(k_9) \\
 \\
 \text{IMAG} &= X_I(0)\sin(k_0) + \\
 &(X_I(1)+X_I(18))\sin(k_1) - (X_R(1)-X_R(18))\cos(k_1) + \\
 &(X_I(2)+X_I(17))\sin(k_2) - (X_R(2)-X_R(17))\cos(k_2) + \\
 &(X_I(3)+X_I(16))\sin(k_3) - (X_R(3)-X_R(16))\cos(k_3) + \\
 &(X_I(4)+X_I(15))\sin(k_4) - (X_R(4)-X_R(15))\cos(k_4) + \\
 &(X_I(5)+X_I(14))\sin(k_5) - (X_R(5)-X_R(14))\cos(k_5) + \\
 &(X_I(6)+X_I(13))\sin(k_6) - (X_R(6)-X_R(13))\cos(k_6) + \\
 &(X_I(7)+X_I(12))\sin(k_7) - (X_R(7)-X_R(12))\cos(k_7) + \\
 &(X_I(8)+X_I(11))\sin(k_8) - (X_R(8)-X_R(11))\cos(k_8) + \\
 &(X_I(9)+X_I(10))\sin(k_9) - (X_R(9)-X_R(10))\cos(k_9)
 \end{aligned}$$

19 POINT DFT INPUT OPTIMIZATION

FIG. 3D

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**FIG. 4A**



192 POINT DFT USING PFA

FIG. 4B

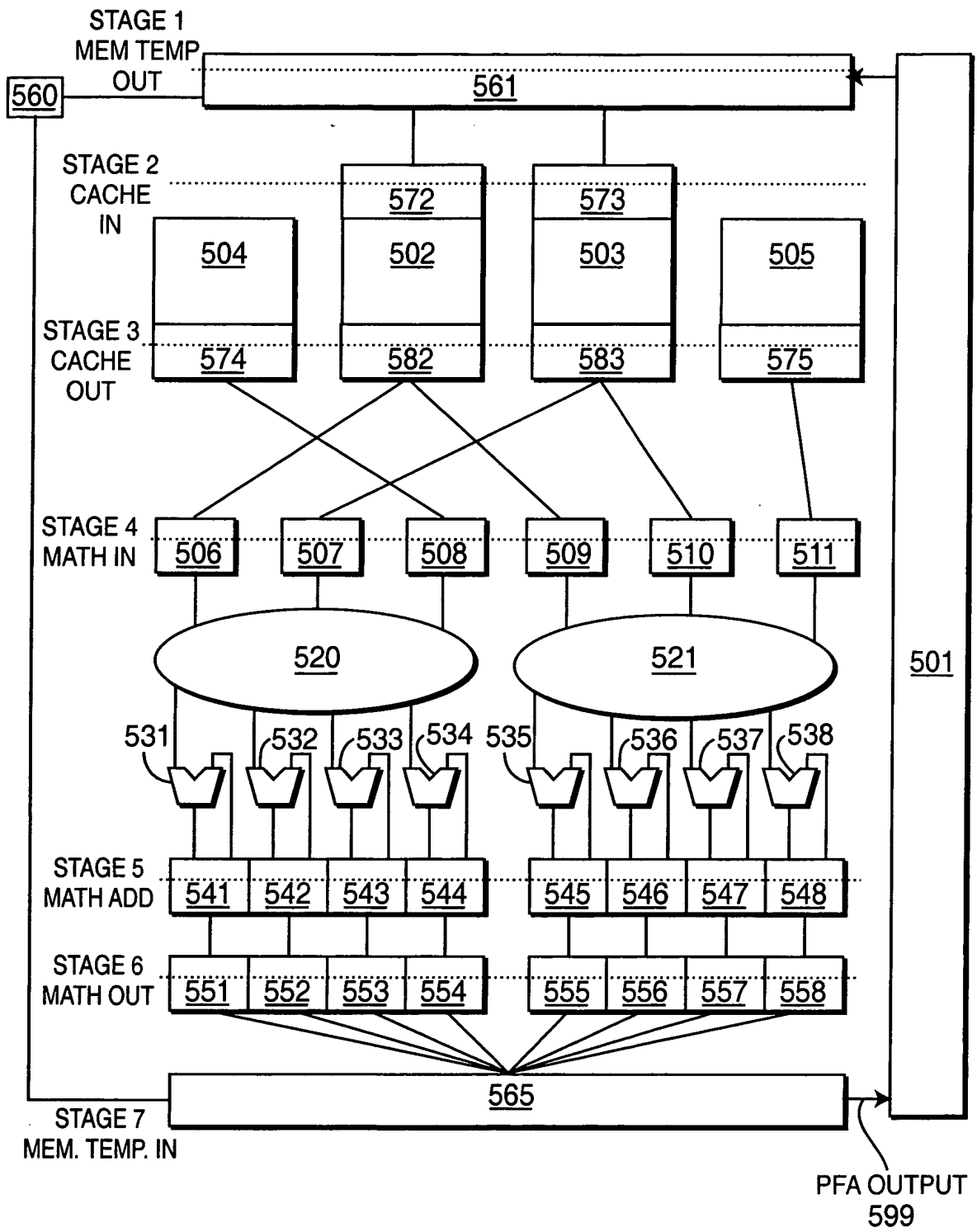


FIG. 5

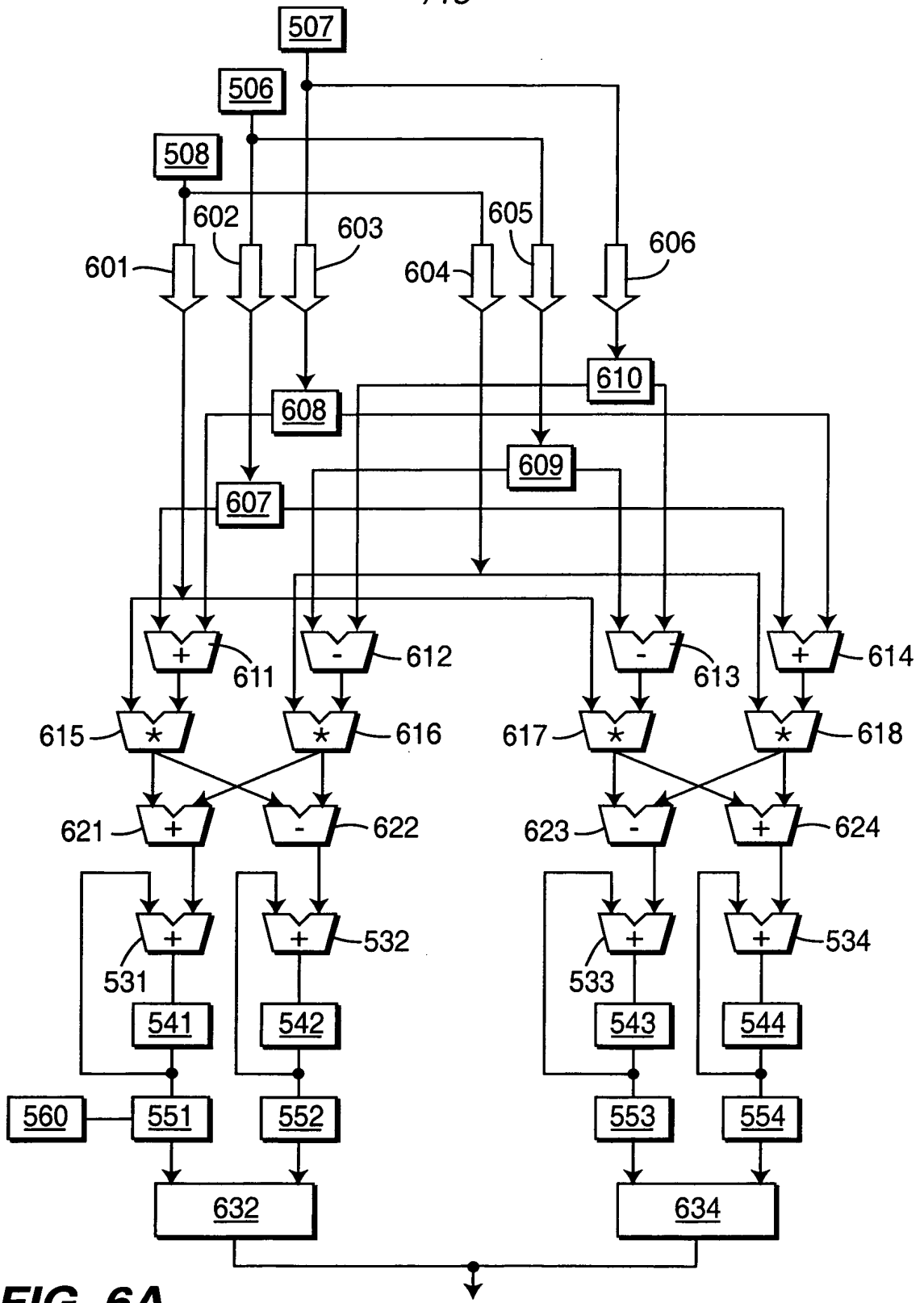


FIG. 6A

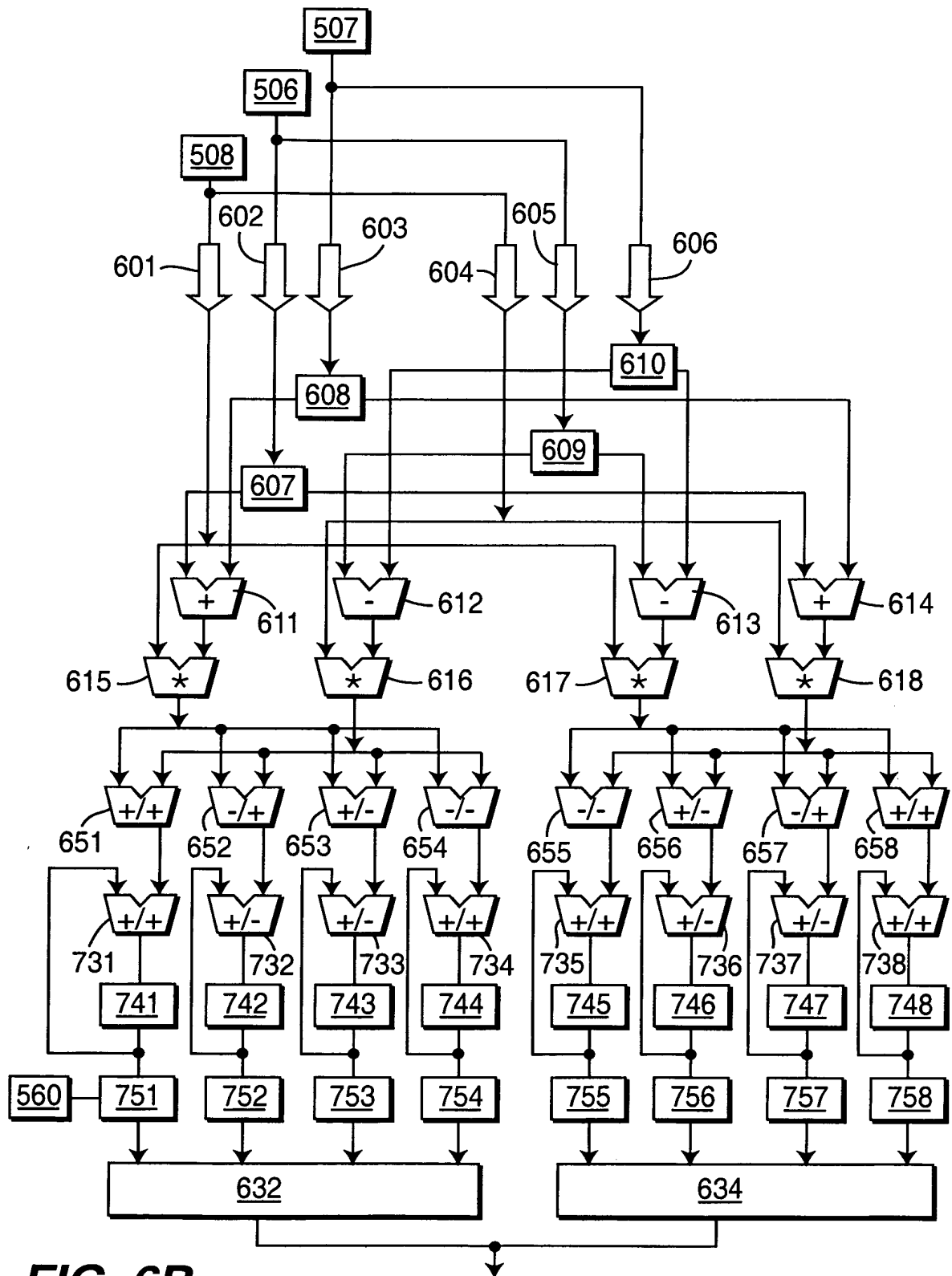


FIG. 6B

STAGE	CLOCK->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	MEM TEMP OUT 561	0	1	2	3	4	5	6	7																								
2	Cache In 572		0	1	2	3	4																										
	Cache In 573									5	6	7																					
3	Cache Out 582																																
	Cache Out 583																																
	Twiddle 574																																
	Twiddle 575																																
4	Math In 506																																
	Math In 507																																
	Math In 508																																
	Math In 509																																
	Math In 510																																
	Math In 511																																
5	Math Add 541																																
	Math Add 542																																
	Math Add 545																																
	Math Add 546																																
6	Math Out 551																																
	Math Out 552																																
	Math Out 555																																
	Math Out 556																																
7	MEM TEMP IN 565																																

8 POINT DFT TIMING

FIG. 7